

LEARNING TO INVESTIGATE STUDENTS' MATHEMATICAL THINKING: THE ROLE OF STUDENT INTERVIEWS

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Interviewing students, though a common and popular activity in teacher education programs has been scarcely researched as a strategy to prepare prospective teachers for mathematics teaching. This study explores the role of interviews as occasions for prospective elementary school teachers to learn three essential practices in the teaching of mathematics—questioning, listening, and responding. Two orientations to interviewing students used by the participants in the study are described and illustrated. Their reported insights focused more prominently on the practice of listening and interpreting students' mathematical ideas which raises questions about structures and designs of the interview experience so that the practices of questioning and responding become more prominent

Teaching in the ways that are envisioned in the mathematics reform documents (NCTM, 2000) where teachers ask for, listen to, and make sense of students' ideas require a host of skills, knowledge and dispositions that are not well understood. They require teachers to "comprehend students' thinking, their interpretations of problems, their mistakes ... and they must have the capacity to probe thoughtfully and tactfully" (Cohen, 1989, p. 75). Learning about students and their ways of thinking, therefore, is inarguably one of the most important domains of knowledge for teaching (Shulman, 1987). From planning lessons, to asking questions, to facilitating class discussion, teachers' knowledge of and ability to investigate students' thinking, can make a difference in the kinds of learning opportunities that are offered to students in the classroom (Henningsen & Stein, 1999; Fenemma et al, 1996). How and where teachers learn these competencies, however, has proven to be an elusive question.

Conducting interviews with students is one strategy that has been proposed to help prospective teachers practice and learn questioning techniques (Moyer & Milewicz, 2002) and learn about students' mathematical thinking (Schorr & Ginsburg, 2000). Similar to previous proponents we consider interviews as a valuable strategy in preservice teacher education. Although conducting interviews differ in significant ways from the challenges and demands of actual classroom practice, it is a context for learning and practicing skills such as questioning, listening, and responding that are essential in the classroom. Although research in recent years has seen a surge of interest in strategies to help prospective teachers learn these essential strategies (e.g., first author, 2000; second author, 1999), interviews with students though a very common and popular strategy in teacher education courses, have been scarcely researched both in terms of their design and their effectiveness or impact. In this study we explore preservice teachers' approaches to interviewing students as well as the kinds of insights they report as having gained from their interview experience.

Data Sources and Analysis

To explore the question of how interviewing students could become occasions for prospective teachers to learn to investigate students' mathematical ideas we draw upon our own experience teaching elementary and secondary mathematics education courses. The data we report here comes from one group of prospective teachers in the first author's elementary mathematics methods course. This course is field-based, that is, the TE students are placed in a local school 2 hours/week and attend class 3 hours/week. The participants of this study were attending a course that was offered during the fall of one academic year. Participants were 18 elementary preservice teachers attending the course in their senior year as undergraduates and prior to their year-long internship placement.

The Interview Task

The preservice teachers conducted mathematics interviews with children from their local field placement elementary schools. Number sense was the topic chosen for the interviews, in particular, the interview protocol provided to the prospective teachers focused on a doubling task (Kelleher, 1996) which investigates students' mental computational strategies when doubling numbers. The interview task was presented to the students as follows:

Look in your field classroom and in their mathematics textbook to learn about how these help students develop number sense and collect student work to find out about how children make sense of numbers.

Write:

- (1) Describe an activity from your field placement classroom, or from their textbook and/or teachers' guide, and explain how it helps students develop number sense.
- (2) Write about what you learned from interviewing a student about what they understand and can do with numbers. Use the sample interview in the back as a resource and use Chapter 6 and 9 to help you interpret your findings.
- (3) Talk about what you learned, found challenging and insightful as an interviewer

The sample interview provided to the preservice teachers did not include the specific questions that they were to ask or in what order they were to ask them, instead it stated the goal of the interview and what they might investigate with the task. It also included some advice about interviewing, such as a reminder to consistently use probes, to give students adequate time to think, and avoid validating student's responses by saying "That's right", or "Good!" If you are compelled to say something, you may use less evaluative feedback such as "That's interesting."

Sample Interview Task

This task asks students to mentally double numbers. It is designed to help us learn about the students' comfort and facility with numbers as well as to explore the students' strategies for doing mental computations. You might begin by asking the students to double 2, then 4, then 8, and so on. Always remember to ask students to explain how they figured their answers. Beware that some students might need clarification of what is

meant by doubling and might need an example (using fingers or counters). In terms of what to look for in your analysis, it is interesting to note:

- (a) What is the largest number that the student can double mentally?
- (b) How does the student handle the numbers that are “easier” to double (e.g., multiples of 5 and 10) as opposed to the “tougher” numbers (e.g., numbers that require “carrying” or regrouping such as 17)?
- (c) Is the student’s strategy a broad or a limited strategy?
- (d) What sort of manipulatives (including how the student uses his/her fingers) does the student use to figure out the question?
- (e) What do the student’s facial expressions and non-verbal cues suggest about his/her level of confidence and engagement with the task?

In preparation to their interviewing experience, several in-class experiences were designed to help preservice teachers plan and prepare their interviews. Preservice teachers watched three sets of video clips showing one-on-one interviews with students. The first two clips were two 5-7 minutes of videos of the first author interviewing two first grade students with the doubling task. The third clip was a video from the MACT (1990) materials where an interviewer is asking fourth through sixth grade students to calculate subtractions mentally and with paper and pencil. Following the viewing of the videos, the preservice teachers and instructor discussed examples of questions that gave good insight into students’ thinking, whether the students’ responses were conceptual or procedural in nature, and to discuss which questions they would like to ask the students that were not asked by the interviewer.

Data sources and analysis

The class discussion around the aforementioned videoclips was audiotaped. Observation notes from two graduate students were also collected to gather impressions of the participants’ orientations towards interviewing. These first impressions were used as an analytical lens and guide to the later analysis of the written reports. These reports were typically 3-5 pages in length. These written reflections were read and examined for constructs, themes, and patterns in preservice teachers’ orientations towards interviewing students and their reported insights. The researchers coded the themes using a constant comparative method (Strauss, 1987). The data were clustered around the most salient and recurring theme across the 18 participants. A framework that has been previously used by the authors to look at preservice teachers’ learning in other contexts and that focus on their “questioning, listening, responding” practices (see second author, 1999) also emerged as a useful framework to organize and cluster the patterns that arose in this context.

RESULTS

Our initial observations and impressions of what preservice teachers’ attended to and ignored when they watched others conduct an interview were similar to those we have made in our previous courses and that have been made by others. The preservice teachers’ reactions to the “mental vs. paper and pencil interview” were of surprise that the young students in the video could mentally figure out the subtraction problem much

more easily than with paper and pencil. This tends to be a surprise because the written algorithm is an explicit part of the elementary mathematics curriculum, whereas mental computation and estimation is something that students tend to learn on their own and not as part of the mathematics curriculum that is taught in schools. Another reason, is that having been schooled by traditional mathematics, our preservice teachers tend to rely on computational procedures than their own sense making.

Seeking explanations as to why this phenomenon might happen, the preservice teachers tend to raise questions about the validity of the interview process, for instance whether the students were nervous or felt on the spot. They also say that the interviewer was not as supportive or encouraging when the students got an incorrect answer and this could have contributed to the students' difficulty with the written task. They are also outraged that the interviewer asks some of the students (who cannot tell whether their answer is right) whether they would like to check it with the calculator. Many of our preservice teachers tend to see this question as an attempt to embarrass the student for being wrong rather than as a way of challenging the students to rethink their solution.

Yet after those initial reactions subsided, and with further questioning by the instructor, the preservice teachers discussed the students' thinking beyond whether it was correct or not, and wondered about what other questions the interviewers could have asked. For instance, one preservice teacher analyzed the strategy used by one of the students in the doubling interview and brainstormed questions they could further ask the students.

I thought it was interesting how he did 19 plus 19 cause like at first I thought he was going to do how Julianne did it: $20 + 20$ is 40 and subtract two to get 38. But he did it quite differently, he broke down the 19, and said $19 + 10$ is 29 and then counted up nine more.

Orientations to Interviewing

Preservice teachers' approaches to interviewing revealed two distinct patterns or orientations: evaluative and inquiry. These terms are meant to reflect the preservice teachers' focus either on the product or the process of the students' thinking. In this study, approximately two thirds of the participants used an evaluative orientation, and one third conducted inquiry-oriented interviews. The evaluative approach is one that is similar to Stigler and Hiebert's (1999) characterization of some teachers' teaching practice as "rapid-fire questions," and that Moyer and Milewicz characterize as "checklisting." In this evaluative mode, the interviewer moves quickly through the interview and asks few or no follow-up questions. This interviewer may also be observed instructing rather than assessing by either explicitly showing students or by asking leading questions.

The preservice teachers in the inquiry orientation on the other hand, were focused on gaining access to the students' thinking and used probing questions regardless of the correctness of the students' response. Consider the following excerpts from two reported interview transcripts (PT: preservice teacher and S: student). In the first example, the preservice teacher moves the student quickly to calculating on paper and pencil after asking only two questions that the student is unable to answer correctly, whereas in the

second example, the preservice teacher continues to probe into the students' response to her first question.

Excerpt One

PT: Can you double 45 for me?

S: (long pause) I don't really know, but it's interesting.

PT: Okay, can you double the number 14 for me?

S: 14 is16.

PT: You think that the double of 14 is 16, can you try that problem on paper?

Excerpt Two

PT: What is Fifteen doubled?

S: ...thirty.

PT: Thirty. What did you do with your hands? You were doing something.

S: I did this.

PT: So, hm...how...So, you counted...

PT: With my fingers...

PT: How did you count? How did you count with your fingers?

S: I go like...hm, fifteen, sixteen, seventeen, eighteen, nineteen, twenty, twenty-one, twenty-two, twenty-three, twenty-four, twenty-five, twenty-six, twenty-seven, twenty-eight, twenty-nine, thirty.

PT: Good. So, how do you know when to stop counting?

S: Because when I get to...when I got to ten I know five more.

Learning and Insights

Regardless of how well or not preservice teachers conducted the interviews or their orientation to interviewing, all the preservice teachers in this study had opportunities to reflect on their learning and insights. Many talked about their insights into students' thinking and could be seen analyzing in more or less detail the kinds of responses the students gave to their questions. Others talked about their insights into the interviewing process and discussed how they were challenged by it. Preservice teachers' insights were categorized using the questioning, interpreting, responding framework alluded to earlier. Most preservice teachers' reflections focused on the "listening" part of the framework that is preservice teachers mostly wrote about what the students said, seemed to understand or be confused about. The following example serves to illustrate.

One interesting answer I got was when I asked one of the girls what $12 + 12$ is, and she answered 24, and I asked her how she got that. She told me that she knows what $10+10$ is, and what $2+2$ is, so she just put them together. This tells me that she has those 5 and 10 "anchors" in her head, and she knows how to build from them. On the other hand, when I asked a bit more difficult question—what is $19+19$ —all three of the children had trouble with doing it mentally.

Reflections on their questioning and responses to students' answers, on the other hand, were less prominent. Only 8 preservice teachers explicitly wrote reflections that could be

placed in those two other categories. One preservice teacher, for instance wrote: “If I were to do another interview, I would plan to ask more follow up questions in hopes of learning more about the students’ thinking.” And another one wrote: “I learned that I need to work on how to better explain and simplify questions for younger students and meet them at their level of understanding.” Still a third wrote:

I also learned some important lessons about myself through the math interview. I was often tempted to guide Virginia’s thinking the way I wanted it to go. I had to hold myself back not to interfere. Fortunately, that fleeting moment of frustration was quickly replaced with admiration for Virginia’s careful response. She had made perfect sense of the problem despite my inner concern that she had mixed things up by not seeing it my way.

CONCLUSION

This study supports the claim others have also made (Moyer & Milewicz, 2002; Schorr & Ginsburg, 2000) that opportunities to conduct interviews with students around a mathematical task provide prospective teachers with multiple opportunities to learn about students’ mathematical ways of thinking and about their unspoken teacher tendencies. We offer that the two approaches to interviewing uncovered in this study might be used as indicators of preservice teachers’ teaching practice before they teach in a real classroom. We can imagine further refining these categories to provide preservice teachers with feedback and further experiences that would help move their orientations towards inquiry rather than evaluation of students’ thinking. Results of this study show that interviewing students provide preservice teachers with opportunities to learn and practice questioning techniques, analysis of students’ mathematical work, and to reflect on these practices. Careful design, structure, and support of the interview experience, however is very important. The design and structure put in place for this study proved to be insufficient to move all the participants towards an inquiry orientation, and to focus everyone’s attention onto their questioning and responding practices. Structuring opportunities that focus more prominently on these elusive aspects of the experience would greatly increase the potential of interviews as contexts for preservice teachers’ learning.

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